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Phosphorous and Foliar Applied Nitrogen Improved Productivity and Quality of Potato

Rashid Waseem Khan Qadri[1], Imran Khan[2*], Muhammad Muzammil Jahangir[1], Umair Ashraf[3], Ghufrana Samin[4], Ammara Anwer[1], Muhammad Adnan[1], Mohsin Bashir[1]

[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan
[2]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
[3]Department of Crop Science and Technology, College of Agriculture, South China Agricultural University, Guangzhou, China
[4]University of Engineering and Technology (Lahore) Faisalabad Campus, Faisalabad, Pakistan
Email: [*]agronomist786@hotmail.com

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Abstract

Growth, yield and quality of potato are greatly affected by its nutritional management. Foliar application of urea reduces nitrogen losses and increases plant nitrogen use efficiency. This study was therefore planned to evaluate the effect of soil applied phosphorus (DAP) and foliar application of nitrogenous fertilizer (urea) on growth, yield and quality of potato. Experiment was comprised of four different treatments of phosphorus (DAP, 46% P) and nitrogen (urea, 46% N) including a control. Treatments were T_0 (DAP 160 + Urea 300 kg/acre), T_1 (DAP 160 + Urea 5 kg/acre), T_2 (DAP 100 + Urea 6 kg/acre) and T3 (DAP 120 + Urea 8 kg/acre). DAP fertilizer was given as basal dressing at the time of sowing. Foliar applications of nitrogenous fertilizer (urea) were given after 30 of sowing with one week interval in five split doses. Results indicated that T_3 remained better regarding productivity and quality of potato. The overall fertilizer efficacy regarding yield and quality was: $T_3 > T_2 > T_1 > T_0$. However, Vitamin C was found maximum in T_0.

Keywords

Nitrogen, Potato Tuber, Phosphorous, Quality, Yield

1. Introduction

Potato (*Solanum tuberosum* L.) is an important member of the family Solanaceae. It is grown and consumed all

[*]Corresponding author.

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around the world and is one of the main vegetable cash crop [1]. In Indo-Pak subcontinent, potato was introduced by Portagues and British, who started its cultivation in 19th century. It is grouped with minor crops but consumed as table food in almost every household and thus listed as sensitive food item [2]. After cereal crops including maize, wheat and rice, potato is ranked as the 4th most important food crop in the world. Potato is rich source of carbohydrates and starch. As potato is an integral part of the global food system, it is cultivated throughout the world. Diverse climatic and agro-ecological conditions of Pakistan allow production of potato almost throughout the year. Potato is a very nutritious food which requires less land, grows quickly and easily even in harsh conditions [3]. Importance of potato is increasing day by day in our country due to increasing population pressure [4].

In Pakistan, farmers takes three crops of potato annually as it is grown in plains and mountains of the country due to different ecological conditions [5]. Main potato growing areas are present in Punjab province. About 86% of the potato growing areas in the country are present in Punjab and Punjab province produces about 88.3% of the whole potato production in the country. In Pakistan, potato production was 3393 thousand tons from an area of 185 thousand hectares in 2011-12; while in 2012-13, potato production was 3767.2 thousand tons from an area of 172 thousand hectares, *i.e*. in the country, potato production has increased about 11% in one year. One of the most important and expensive input in crop production is fertilizer. In different agricultural regions of the Pakistan, balanced use of fertilizers has increased the yield of field crops from 30% - 50%. In general, agricultural lands in Pakistan are low in nitrogen (N), phosphorous (P) and potassium (K) contents. However, N and P deficiency is more severe than K [6].

Nitrogen fertilizer application is considered as one of the most important factor which limits production of potato [7]. Nitrogen has very low use efficiency and is lost easily due to which crop cannot use it and hence it increases economic concerns as crop production is less. Nitrogen which is not used by the crop is lost through leaching, runoff, volatilization and denitrification. This lost nitrogen increases contamination of water and gas emissions from greenhouse. If nitrogen losses are reduced, crop nitrogen-use efficiency can be enhanced [8]. The nitrogen losses can be minimized by using appropriate method of its application. Foliar spray of nutrients is an important substitute for soil fertilization and a good tool in crop management to maximize yields of crops. In soil fertilization, plants absorb nutrients by root and they are translocated to the upper parts while in foliar application, nutrients enter the leaf cuticle and then in the cells. Thus, crop shows immediate response in less time in case of foliar sprays [9]. Foliar fertilization of nutrients *i.e*. mineral or organic is an important practice because it affects the growth of foliage, formation of tubers and quality of potato yield [10]. Foliar application of urea is more beneficial as it depends less on soil conditions and in saline or dry soils when root nitrogen uptake is impaired, plants can easily take nitrogen from foliar application [11]. Foliar application of urea can enhance yield of tuber as it provides an opportunity to fertilize the crop late in the season [12].

Phosphorus plays an important role in plant nutrition particularly it helps to increase early crop growth [13]. Potato respond differently depending upon soil phosphorous contents coupled with soil pH [14]. Potato yield, number of tubers and size of tubers are greatly affected by phosphorus fertilization. Tuber set is also increased with application of phosphorus [15] [16].

Looking at the importance of nitrogen and phosphorus application in potato crop to increase its yield and also keeping in mind the losses occurs due to the judicious use of nitrogen and phosphorus fertilizer, we therefore conduct an experiment to minimize the nitrogen use through its foliar application and also study its impact on crop yield and quality parameters.

2. Materials and Methods

2.1. General Details

The present study was carried out in Vegetable Experimental Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad during 2013-14. The experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. Plant material which was used in this research project includes potato variety Lady Rosetta which is used for processing purpose and provided by private enterprise “Kurleez”, Lahore, Pakistan. This variety is round, red skinned and it becomes mature earlier. Soil was prepared well before planting seed tubers. Ridges were made and tubers were planted on ridges. Each ridge had 28 plants and 2 ridges were taken as treatment unit. Tubers were treated with Monceren of Bayer Crop Sciences for the control of *Rhizoctonia solani*. The experiment consist of treatments viz; T_0 = 300 kg/acre Urea + 160 kg/acre DAP (Both

Soil Applied Farmer practice) T_1 = 5 kg/acre Urea (foliar application) + 160 kg/acre DAP T_2 = 6 kg/acre Urea (foliar application) + 100 kg/acre DAP, T_3 = 7 kg/acre Urea (foliar application) + 120 kg/acre DAP. Nitrogen and phosphorus was applied using commercially available Urea and DAP (Di ammonium phosphate). In each treatment whole DAP was applied at sowing time. For T_0 Nitrogenous fertilizer urea was applied in 6 splits @ 50 kg Urea per split after sowing the seed tubers. First application was made after 25 days of sowing seed tubers and then remaining five applications were made after every 7 days interval. In Remaining each treatment foliar application of Urea was made after 30 days of sowing seed tubers and then another four foliar sprays were done after one week interval. Other cultural practices like weeding and watering was done as per requirement. All other intercultural practices like weeding and disease control was done in all treatments. The crop was sown on 22 October; 2013 and was harvest on 26th February, 2014. The data regarding number of tubers per plant, number of tubers per plot, tuber yield per plant, per plot and per hectare, dry weight of tubers per plant, diameter of tubers, Volume of tubers marketable yield was calculated using standard procedures.

2.2. Determination of Nutrient Elements

2.2.1. Total Nitrogen (N)

Total N was determined according to Chapman and Parker [17] method, which involved digesting the plant material with concentrated sulphuric acid (H_2SO_4) and digestion mixture (digestion mixture, comprising K_2SO_4, $CuSO_4$ and $FeSO_4$ in ratio of 10:0.5:1).

2.2.2. Phosphorus and Potash Estimation

The digestion for estimation of P and K was done according to the method described by Yoshida *et al.* [18]. Potassium was determined by flame photometer and phosphorus by spectrophotometer according to the method described by Chapman and Parker [17].

2.2.3. Chemical Analysis

For chemical analysis, tuber juice of each sample, consisting of 5 fruit was extracted with the help of electric juicer.

2.2.4. Ascorbic Acid (mg/100 g FW)

Vitamin C contents of juice were determined following the method described by Ruck [19].

2.2.5. Statistical Analysis

The data collected was analyzed statistically by using the computer software DAASTAT. Least significant difference (LSD) test at 5% probability level was used to compare the treatment means [20].

3. Results and Discussion

3.1. Yield and Related Attributes

Phosphorous and foliar applied nitrogen significantly improved the yield and related components of potato tubers. Results showed that maximum tuber yield per plant/per plot and per hectare as well as dry weight of tubers per plant and Marketable yield was recorded in T_3 followed by T_2, T_1 and T_0, respectively. However, tubers per plot were found highest in T_2 while lowest in control (T_0). Further perusal of data elaborated that tubers per plant and diameter of tubers are highest in T_2 but do not differ significantly from T_3, nonetheless differs noticeably from T_1 and T_0 (**Table 1**). So, foliar application of fertilizer remains far better than soil applied fertilizer regarding potato yield. This probably suggests that potato supplied foliar nitrogen increased leaf nitrogen contents, thus accelerates photosynthesis and develop a strong source sink relationship. Moreover, by increasing foliar applied nitrogen and phosphorus concentrations, yield increased linearly that showed a direct relationship of nitrogen and phosphorous to tuber yield up to a certain extent. Hence mode of fertilizer application also matters a lot specifically when plants need quick access to nutrients. This is an interesting finding that fertilizer dose for foliar application is too low than soil applied nitrogen as in control. So, in another way it enhances fertilizer use efficiency and reduced nutrients loses. However, here is a still need to find an optimum level of foliar applied fertilizer as we can apply not only nitrogen but also phosphorous and potassium through fertigation or foliar application that resultantly quickens plant access to nutrients that otherwise are soil moisture dependent. Rizk *et al.*

Table 1. Effect of foliar application of urea and different doses of soil applied DAP on the productivity of potato.

Treatments	Tubers per plant	Tubers per plot	Tuber yield per plant (g)	Tuber yield per plot (kg)	Tuber yield per hectare (tons)	Dry weight of tubers per plant (g)	Diameter of tubers (mm)	Marketable yield (kg)
T_0	6.84 ± 0.37 c	379 ± 17.32 d	402.01 ± 12.62 d	22.7 ± 0.73 d	23.65 ± 0.28 d	92.08 ± 1.13 d	4.50 ± 0.10 b	19.30 ± 0.53 d
T_1	8.58 ± 0.20 b	480.67 ± 10.10 c	449.61 ± 5.69 c	25.16 ± 0.35 c	25.13 ± 0.13 c	103.82 ± 0.75 c	4.67 ± 0.16 b	21.61 ± 0.10 c
T_2	10.37 ± 0.38 a	573.67 ± 15.07 a	694.99 ± 3.26 b	38.5 ± 0.29 b	38.19 ± 0.36 b	161.36 ± 3.8 b	5.10 ± 0.21 a	34.81 ± 0.25 b
T_3	9.93 ± 0.29 a	555.67 ± 16.15 b	730.80 ± 7.66 a	40.83 ± 0.44 a	39.76 ± 0.56 a	167.51 ± 2.65 a	5.10 ± 0.06 a	36.63 ± 0.36 a
LSD ($p < 0.05$)	**1.23**	**41.99**	**28.68**	**1.78**	**1.10**	**8.86**	**0.47**	**1.27**

Values sharing a letter in common within a column do not differ significantly at 5% level of probability. The values indicate the means of three replicates ± S.E. T_0 = 300 kg/acre Urea + 160 kg/acre DAP (Both Soil Applied Farmer practice), T_1 = 5 kg/acre Urea (foliar application) + 160 kg/acre DAP, T_2 = 6 kg/acre Urea (foliar application) + 100 kg/acre DAP, T_3 = 7 kg/acre Urea (foliar application) + 120 kg/acre DAP.

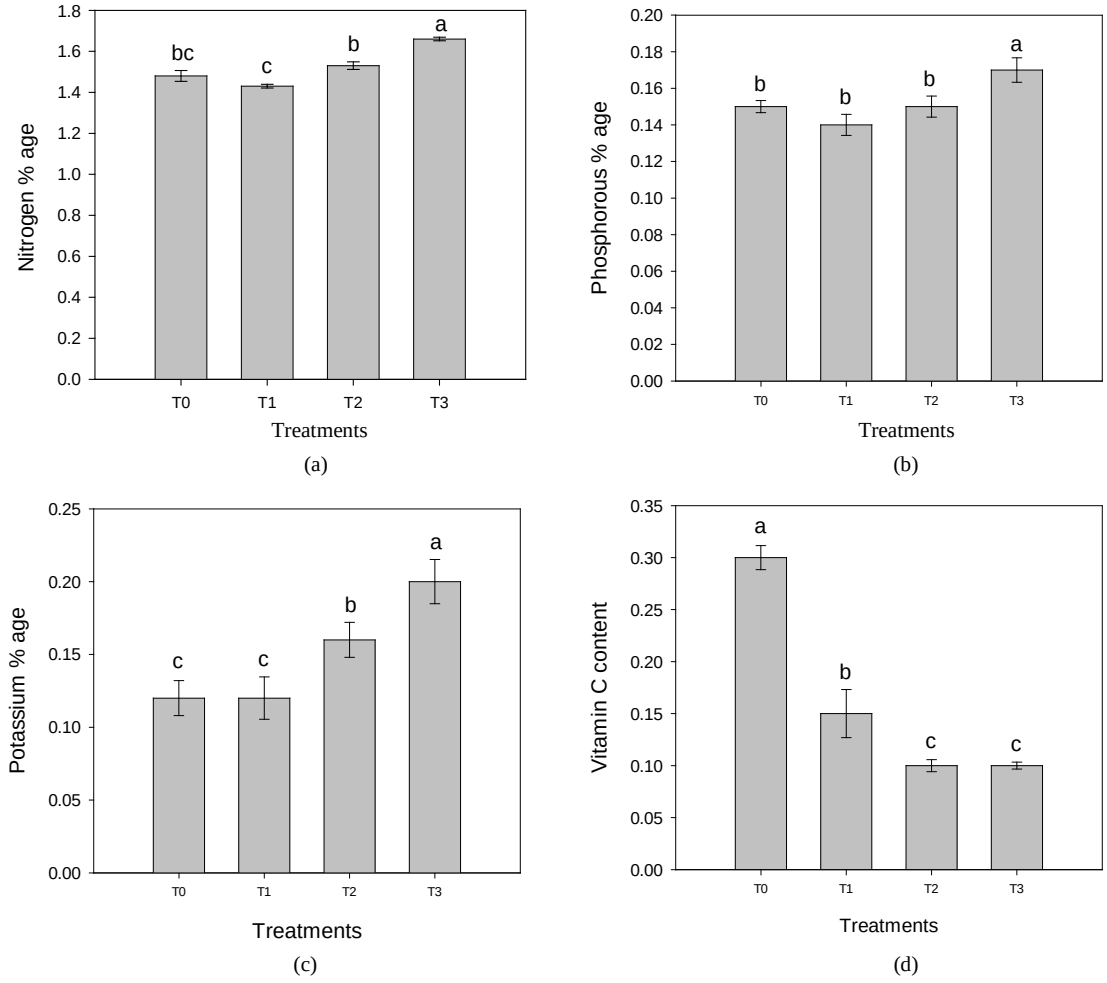

Figure 1. Effect of foliar application of urea and different doses of soil applied DAP on (a) Nitrogen % age (b) Phosphorous % age (c) Potassium % age and (d) Vitamin C contents of potato tubers. Vertical bars above means represent standard error of three replicates. T_0 = 300 kg/acre Urea + 160 kg/acre DAP (Both Soil Applied Farmer practice), T_1 = 5 kg/acre Urea (foliar application) + 160 kg/acre DAP, T_2 = 6 kg/acre Urea (foliar application) + 100 kg/acre DAP, T_3 = 7 kg/acre Urea (foliar application) + 120 kg/acre DAP.

[21] studied the effect of foliar application of urea at two different levels on growth, yield and quality parameters of potato. They found that maximum numbers of tubers per plant were produced at higher rate of nitrogen. Rosen and Bierman [22] explored the influence of phosphorus on yield of potato and reported that total yield was increased with application of phosphorus but marketable yield was reduced with the application of greater quantity of phosphorus as it produced greater number of small sized tubers. Kolota and Osinska [23] investigated the efficiency of different field vegetables at different rates of foliar application of urea. Results obtained indicated that foliar application of fertilizer increased marketable yield of vegetables significantly.

3.2. Quality Attributes

Quality of the potato tubers significantly enriched with mode of fertilizer application as well as fertilizer dose. Highest N, P and K contents were recorded in T_3 that differs considerably from T_2, T_1 and T_0. However, minimum concentration of these primary nutrients was observed in T_0 (control). Interestingly, vitamin C contents were recorded maximum in T_0 followed by T_1, T_2 and T_3 (**Figure 1**). Due to nutrient availability and quick access of plant to nutrients, it not only improved growth but also the quality of the potato tubers. Higher N, P and K contents in T_3 explored that plants retained the nutrients and then transported to the sink at as plant grows towards maturity. Moreover, foliar applied nitrogen was also not dependent on soil moisture contents. Nonetheless, as phosphorous was applied on soil surface, but quick access to nitrogen; make a pull for phosphorous by enhancing photosynthetic process. Further there may be relationship between these three nutrients (N, P and K) but not explored in this study. Yildrim *et al.* [24] investigated the effect of soil and foliar application of urea on broccoli at four different levels. They found that application of nitrogen increased all the nutrients in broccoli. Hence, nitrogen content was increased with the application of nitrogen to the broccoli.

4. Conclusion

It can be concluded from this study that foliar application of fertilizer is far better than soil application. It not only improves plant yield and quality but also nutrient efficiency.

References

[1] Ewing, E.E. (1997) The Physiology of Vegetable Crops (Ed: H.C. Wein). CAB Intern. UK, 295-344.

[2] Rana, Z.H. and Rehman, R.S. (1993) Policy Imperatives: Stabilization of Production and Price Swings of Potato and Onion Crops in Pakistan. *The Pakistan Development Review*, **32**, 737-749.

[3] Trade Development Authority of Pakistan (2010) Report on Potential Markets of Potato. http://www.tdap.gov.pk/product_report_presentations.php

[4] Malik, M.N. (1994) Horticulture. National Book Foundation, Islamabad, 269-271.

[5] Malik, N.J. (1995) Potatoes in Pakistan. Pak. Swiss Potato Development Project, Pak. Agric. Res. Council, Islamabad, Pakistan, 80-85.

[6] Wakeel, A. (2014) Critical Review of Research on Soil K and Crops' Response to K Fertilizers in Pakistan: Perspectives and Opportunities. *International Potash Institute*, **37**, 16-21.

[7] Tran, S.T. and Giroux, M. (1991) Effects of N Rates and Harvest Dates on the Efficiency of N-Labelled Fertilizer on Early Harvested Potatoes (*Solanum tuberosum* L.). *Canadian Journal of Soil Science*, **71**, 519-532. http://dx.doi.org/10.4141/cjss91-050

[8] Engelsjord, M.E., Fostad, O. and Singh, B.R. (1997) Effects of Temperature on Nutrient Release from Slow-Release Fertilizers. *Nutrient Cycling in Agroecosystems*, **46**, 179-187. http://dx.doi.org/10.1007/BF00420552

[9] Fageria, N.K., Filho, M.P.B., Moreira, A. and Guimar, C.M. (2009) Foliar Fertilization of Crop Plants. *Journal of Plant Nutrition*, **32**, 1044-1064. http://dx.doi.org/10.1080/01904160902872826

[10] Eleiwa, M.E., Ibrahim, S.A. and Mohamed, M.F. (2012). Combined Effect of NPK Levels and Foliar Nutritional Compounds on Growth and Yield Parameters of Potato Plants (*Solanum tuberosum* L.). *African Journal of Microbiology Reserach*, **6**, 5100-5109.

[11] Gooding, M.J. and Davies, W.P. (1992) Foliar Urea Fertilization of Cereals: A Review. *Fertilizer Research*, **32**, 209-222. http://dx.doi.org/10.1007/BF01048783

[12] Millard, P. and Robinson, D. (1990) Effect of the Timing and Rate of Nitrogen Fertilization on the Growth and Recovery of Fertilizer Nitrogen within the Potato (*Solanum tuberosum* L.) Crop. *Fertilizer Research*, **21**, 133-140.

http://dx.doi.org/10.1007/BF01087422

[13] Jenkins, P.D. and Ali, H. (1999) Growth of Potato Cultivars in Response to Application of Phosphate Fertilizer. *Annals of Applied Biology*, **135**, 431-438. http://dx.doi.org/10.1111/j.1744-7348.1999.tb00871.x

[14] Sanderson, J.B., MacLeod, J.A., Douglas, B., Coffin, R. and Bruulsema, T. (2003) Phosphorus Research on Potato in PEI. *Acta Horticulturae*, **619**, 409-417.

[15] Freeman, K.L., Franz, P.R. and de Jong, R.W. (1998) Effect of Phosphorus on the Yield, Quality, and Petiolar Phosphorus Concentrations of Potatoes (cv. Russet Burbank and Kennebec) Grown in the Krasnozem and Duplex Soils of Victoria. *Australian Journal of Experimental Agriculture*, **38**, 83-93. http://dx.doi.org/10.1071/EA96045

[16] Maier, N.A., McLaughlin, M.J., Heap, M., Butt, M. and Smart, M.K. (2002) Effect of Current-Season Application of Calcitic Lime and Phosphorus Fertilization on Soil pH, Potato Growth, Yield, Dry Matter Content, and Cadmium Concentration. *Communications in Soil Science and Plant Analysis*, **33**, 2145-2165. http://dx.doi.org/10.1081/CSS-120005754

[17] Chapman, D.H. and Parker, E.R. (1961) Determination of NPK Methods of Analysis for Soil, Plant and Waters. Pub. Div. Agri. Univ. of California, USA, 150-179.

[18] Yoshida, S., Fonao, D.A., Cock, J.H. and Gomez, K.A. (1976) Laboratory Manual for Physiological Studies of Rice. 3rd Edition, International Rice Research Institute, Los Banos.

[19] Ruck, J.A. (1961) Chemical Methods for Analysis of Fruits and Vegetables. No. 1154. Research Station Summerland, Research Branch Canada.

[20] Steel, R.G., Torrie, J.H. and Dickey, D.A. (1997) Principles and Procedures of Statistics: A Biometrical Approach. 3rd Edition, McGraw Hill Book Co., New York.

[21] Rizk, F.A., Shaheen, A.M., Singer, S.M. and Sawan, O.A. (2013) The Productivity of Potato Plants Affected by Urea Fertilizer as Foliar Spraying and Humic Acid Added with Irrigation Water. *Middle East Journal of Agricultural Research*, **2**, 76-83.

[22] Rosen, C.J. and Bierman, P.M. (2008) Potato Yield and Tuber Set as Affected by Phosphorus Fertilization. *American Journal of Potato Research*, **85**, 110-120. http://dx.doi.org/10.1007/s12230-008-9001-y

[23] Kolota, E. and Osinska, M. (1999) Efficiency of Foliar Nutrition of Field Vegetables Grown at Different Nitrogen Rates. *Proceedings of the International Conference on Environmental Problems Associated with Nitrogen Fertilization of Field Grown Vegetable Crops*, Potsdam, 30 August-1 September 1999, 87-91.

[24] Yildrim, E., Guvenc, I., Turans, M. and Karatas, A. (2007) Effect of Foliar Urea Application on Quality, Growth, Mineral Uptake and Yield of Broccoli (*Brassica oleracea* L., var. Italica). *Plant Soil and Environment*, **3**, 120-128.

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